

Soyuz 10 Return Samples: Assessment of Air Quality Aboard the International Space Station

The toxicological assessments of 4 dual sorbent tubes (DSTs) and 4 pairs of formaldehyde badges returned aboard Soyuz 10 on October 10, 2005 are reported. Analytical methods have not changed from earlier reports. The recoveries of the 2 less volatile surrogates from the DSTs (including controls) averaged 100 and 100 %; however, ¹³C-acetone was only recovered at an average of 60 %. Correction factors were applied to volatile polar compounds due to limited recoveries by the DSTs. Formaldehyde recoveries from 2 positive controls were 97 and 74%.

The two general criteria used to assess air quality are the total-non-methane-volatile organic hydrocarbons (NMVOCs) and the total T-value (minus the CO₂ and formaldehyde contributions). Control of atmospheric alcohols is important to the water recovery system engineers, hence total alcohols (including acetone) are also shown for each sample. Because formaldehyde is quantified from sorbent badges, its concentration is also listed separately. These four indices of air quality are summarized below:

Module/Sample	Approx. Date	NMVOCs (mg/m ³)	T Value (units)	Alcohols (mg/m ³)	Formaldehyde (ug/m ³)
Lab/DST&Form.	9/8/05	25	3	16 ²	46 ³
SM/DST&Form.	9/8/05	2	0.2	1	25
FGB/DST&Form.	9/30/05	4	1.2	2	26
SM/DST&Form.	9/30/05	1	0.1	1	19
<i>Guideline</i>		<25	<1.0	<5	<120 ¹

¹ A new long-term SMAC has been provisionally accepted by the National Research Council Committee on Toxicology and by the NASA Toxicology Group.

² Ethanol contributed 10 mg/m³ to this value.

³ Counted as an irritant (formaldehyde T value = 46/120 = 0.38).

All formaldehyde concentrations were well within the new long-term SMAC guideline. The Lab samples continue to show slightly higher formaldehyde concentrations than the SM/FGB samples. The Lab sample from September 8th showed unusually high alcohols and a high T value. Ethanol can be episodically high in specific locations, and this comprised most of the elevated total alcohol value. The T value was elevated mostly by methanol (0.28), acetaldehyde (0.99), and traces of acrolein (0.5), methyl furan (0.27), and furan (0.5); however, the low T value found simultaneously in the SM argues that the levels of pollution found in the Lab sample were not widespread in the ISS. One “dirty” sample such as this does not cause any concern for crew health. The T value for irritants (acetaldehyde, acrolein, and formaldehyde) was 1.9, suggesting that the crew might have experienced momentary, mild eye or nasal irritation from the atmospheric contaminants.

Enclosures

[Table 1: Analytical Concentrations of 10S DST Air Samples](#)

[Table 2: T-Value Calculations of 10S DST Air Samples](#)

TABLE 1
ANALYTICAL RESULTS OF
SOYUZ 10S RETURN DUAL SORBENT TUBES AIR SAMPLES

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)			
	AA03933 LAB S/N 1019 09/08/05 @ 05:05 GMT	AA03935 SM S/N 1018 09/08/05 @ 15:15 GMT	AA03934 FGB S/N 1017 09/30/05 @ 09:55 GMT	AA03936 SM S/N 1016 09/30/05 @ 10:00 GMT
TARGET COMPOUNDS (TO-14/POLAR)***				
FREON 12	0.11	TRACE	< 0.07	< 0.05
CHLOROMETHANE	TRACE	TRACE	< 0.07	< 0.05
FREON 114	< 0.07	< 0.05	< 0.07	< 0.05
METHANOL	3	0.2	1	0.1
ACETALDEHYDE	4	ND	0.1	TRACE
VINYL CHLORIDE	< 0.07	< 0.05	< 0.07	< 0.05
BROMOMETHANE	< 0.07	< 0.05	< 0.07	< 0.05
ETHANOL	10	0.7	0.5	0.4
CHLOROETHANE	< 0.07	< 0.05	< 0.07	< 0.05
ACETONITRILE	TRACE	TRACE	TRACE	TRACE
PROPENAL	TRACE	< 0.02	TRACE	< 0.02
ACETONE	1	0.1	0.1	TRACE
PROPANAL	0.11	TRACE	TRACE	TRACE
2-PROPANOL	1	TRACE	TRACE	TRACE
FREON 11	TRACE	< 0.05	< 0.07	< 0.05
FURAN	TRACE	< 0.05	< 0.07	< 0.05
ACRYLONITRILE	TRACE	< 0.05	< 0.07	< 0.05
PENTANE	TRACE	< 0.05	< 0.07	< 0.05
2-METHYL-2-PROPANOL	TRACE	< 0.05	< 0.07	< 0.05
METHYL ACETATE	TRACE	< 0.05	< 0.07	< 0.05
1,1-DICHLOROETHENE	< 0.07	< 0.05	< 0.07	< 0.05
DICHLOROMETHANE	0.12	TRACE	TRACE	< 0.05
3-CHLOROPROPENE	< 0.07	< 0.05	< 0.07	< 0.05
FREON 113	< 0.07	< 0.05	< 0.07	< 0.05
N-PROPANOL	0.14	TRACE	TRACE	< 0.05
1,1-DICHLOROETHANE	< 0.07	< 0.05	< 0.07	< 0.05
BUTANAL	0.075	TRACE	TRACE	TRACE
2-BUTANONE	0.086	TRACE	TRACE	TRACE
1,2-DICHLOROETHENE	< 0.07	< 0.05	< 0.07	< 0.05
2-METHYLFURAN	TRACE	< 0.05	TRACE	< 0.05
ETHYL ACETATE	0.12	< 0.05	< 0.07	< 0.05
HEXANE	TRACE	< 0.05	< 0.07	< 0.05
CHLOROFORM	< 0.07	< 0.05	< 0.07	< 0.05
2-BUTENAL	TRACE	< 0.05	< 0.07	< 0.05
1,2-DICHLOROETHANE	TRACE	< 0.05	< 0.07	< 0.05
1,1,1-TRICHLOROETHANE	< 0.07	< 0.05	< 0.07	< 0.05
N-BUTANOL	0.33	TRACE	< 0.07	< 0.05
BENZENE	TRACE	< 0.05	< 0.07	< 0.05
TETRACHLOROMETHANE	< 0.07	< 0.05	< 0.07	< 0.05
2-PENTANONE	TRACE	TRACE	< 0.07	TRACE
2-METHYLHEXANE	TRACE	< 0.05	< 0.07	< 0.05
2,3-DIMETHYLPENTANE	TRACE	< 0.05	< 0.07	< 0.05
PENTANAL	TRACE	TRACE	TRACE	TRACE
3-METHYLHEXANE	TRACE	< 0.05	< 0.07	< 0.05
1,2-DICHLOROPROPANE	< 0.07	< 0.05	< 0.07	< 0.05
1,4-DIOXANE	< 0.07	< 0.05	< 0.07	< 0.05
TRICHLOROETHENE	< 0.07	< 0.05	< 0.07	< 0.05
2,5-DIMETHYLFURAN	< 0.07	< 0.05	< 0.07	< 0.05

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)			
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HEPTANE	TRACE	< 0.05	< 0.07	< 0.05
4-METHYL-2-PENTANONE	< 0.07	< 0.05	< 0.07	< 0.05
CIS-1,3-DICHLOROPROPENE	< 0.07	< 0.05	< 0.07	< 0.05
2-PENTENAL	TRACE	< 0.05	< 0.07	< 0.05
TRANS-1,3-DICHLOROPROPENE	< 0.07	< 0.05	< 0.07	< 0.05
1,1,2-TRICHLOROETHANE	< 0.07	< 0.05	< 0.07	< 0.05
TOLUENE	1.0	TRACE	< 0.07	< 0.05
HEXANAL	TRACE	TRACE	TRACE	TRACE
MESITYL OXIDE	TRACE	< 0.05	< 0.07	< 0.05
1,2-DIBROMOETHANE	< 0.07	< 0.05	< 0.07	< 0.05
BUTYL ACETATE	TRACE	< 0.05	< 0.07	< 0.05
TETRACHLOROETHENE	TRACE	< 0.05	< 0.07	< 0.05
CHLOROBENZENE	< 0.07	< 0.05	< 0.07	< 0.05
ETHYLBENZENE	TRACE	< 0.05	< 0.07	< 0.05
META+PARA-XYLENES	TRACE	< 0.05	< 0.07	< 0.05
2-HEPTANONE	TRACE	< 0.05	< 0.07	< 0.05
CYCLOHEXANONE	TRACE	TRACE	< 0.07	< 0.05
HEPTANAL	TRACE	< 0.05	< 0.07	< 0.05
STYRENE	TRACE	< 0.05	< 0.07	< 0.05
1,1,2,2-TETRACHLOROETHANE	< 0.07	< 0.05	< 0.07	< 0.05
ORTHO-XYLENE	0.094	TRACE	< 0.07	< 0.05
1,3,5-TRIMETHYLBENZENE	< 0.07	< 0.05	< 0.07	< 0.05
1,2,4-TRIMETHYLBENZENE	< 0.07	< 0.05	< 0.07	< 0.05
1,3-DICHLOROBENZENE	< 0.07	< 0.05	< 0.07	< 0.05
1,4-DICHLOROBENZENE	< 0.07	< 0.05	< 0.07	< 0.05
1,2-DICHLOROBENZENE	< 0.07	< 0.05	< 0.07	< 0.05
1,2,4-TRICHLOROBENZENE	< 0.07	< 0.05	< 0.07	< 0.05
HEXAChLOROBUTADIENE	< 0.07	< 0.05	< 0.07	< 0.05

TARGET COMPOUNDS (TOXIC)				
1,3-BUTADIENE	< 0.07	< 0.05	< 0.07	< 0.05
ETHYLENE OXIDE	< 0.07	< 0.05	< 0.07	< 0.05
CARBON DISULFIDE	TRACE	TRACE	TRACE	TRACE
2-METHYL-2-PROPENAL	TRACE	TRACE	TRACE	< 0.05
3-BUTEN-2-ONE	TRACE	TRACE	TRACE	< 0.05
2-ETHOXYETHANOL	< 0.07	< 0.05	< 0.07	< 0.05
DIMETHYLDISULFIDE	< 0.07	< 0.05	< 0.07	< 0.05
OCTAMETHYLCYCLOTETRASILOXANE	0.36	0.27	0.81	TRACE

NON-TARGET COMPOUNDS				
OCTAFLUOROPROpane	*	*	*	*
1,1,1,2-TETRAFLUOROETHANE	TRACE	< 0.05	< 0.07	< 0.05
CARBONYLSULFIDE	0.18	0.13	0.073	0.11
1-BUTENE	TRACE	TRACE	TRACE	TRACE
TRIMETHYLSILANOL	0.30	TRACE	TRACE	< 0.05
1,3-DIOXOLANE	1.7	TRACE	TRACE	TRACE
HEXAMETHYLCYCLOTRISILOXANE	0.14	0.40	0.50	0.073
LIMONENE	0.070	TRACE	TRACE	TRACE

TOTAL ALCOHOLS PLUS ACETONE	15.5	1.08	1.65	0.55
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TOTAL CONCENTRATION	25	2.4	3.5	1.05
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CHEMICAL CONTAMINANT	CONCENTRATION (mg/m ³)			
	AA03933 LAB S/N 1019 09/08/05 @ 05:05 GMT	AA03935 SM S/N 1018 09/08/05 @ 15:15 GMT	AA03934 FGB S/N 1017 09/30/05 @ 09:55 GMT	AA03936 SM S/N 1016 09/30/05 @ 10:00 GMT
(NON-METHANE HYDROCARBONS)				

* Present, but not quantitated

CONCENTRATION FROM DILUTION ANALYSIS (ITALICS)

< : Value is less than the laboratory report detection limit.

TRACE: Amount detected is sufficient for compound identification only. Calculations are based on one-half of the laboratory report detection limit (1.1 mg/m³ for CO; 0.2 mg/m³ for CH₄; 1.6 mg/m³ for H₂; 0.05 mg/m³ for VOCs; and 0.02 mg/m³ for propenal.)

***Measurements are calibrated by multi-point initial calibration and verified by mid-point continuing calibration.

TABLE 2
ANALYTICAL RESULTS OF
SOYUZ 10S RETURN DUAL SORBENT TUBES AIR SAMPLES

CHEMICAL CONTAMINANT	T-VALUE (180-day SMAC)			
	AA03933 LAB S/N 1019 09/08/05 @ 05:05 GMT	AA03935 SM S/N 1018 09/08/05 @ 15:15 GMT	AA03934 FGB S/N 1017 09/30/05 @ 09:55 GMT	AA03936 SM S/N 1016 09/30/05 @ 10:00 GMT
TARGET COMPOUNDS (TO-14/POLAR)***				
FREON 12	0.00023	0.00005	ND	ND
CHLOROMETHANE	0.00085	0.00061	ND	ND
FREON 114	ND	ND	ND	ND
METHANOL	0.27789	0.01700	0.12633	0.00672
ACETALDEHYDE	0.99400	ND	0.02210	0.00625
VINYL CHLORIDE	ND	ND	ND	ND
BROMOMETHANE	ND	ND	ND	ND
ETHANOL	0.00515	0.00037	0.00023	0.00019
CHLOROETHANE	ND	ND	ND	ND
ACETONITRILE	0.00522	0.00373	0.00522	0.00373
PROPENAL*	0.50000	ND	0.50000	ND
ACETONE	0.02145	0.00285	0.00228	0.00048
PROPANAL	0.02906	0.00694	0.00972	0.00694
2-PROPANOL	0.00473	0.00017	0.00023	0.00017
FREON 11	0.00004	ND	ND	ND
FURAN	0.50000	ND	ND	ND
ACRYLONITRILE	0.01250	ND	ND	ND
PENTANE	0.00006	ND	ND	ND
2-METHYL-2-PROPANOL	0.00029	ND	ND	ND
METHYL ACETATE	0.00029	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND
DICHLOROMETHANE	0.01241	0.00250	0.00350	ND
3-CHLOROPROPENE	ND	ND	ND	ND
FREON 113	ND	ND	ND	ND
N-PROPANOL	0.00139	0.00026	0.00036	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND
BUTANAL	0.01711	0.00568	0.00795	0.00568
2-BUTANONE	0.00285	0.00083	0.00117	0.00083
1,2-DICHLOROETHENE	ND	ND	ND	ND
2-METHYLFURAN	0.26923	ND	0.26923	ND
ETHYL ACETATE	0.00066	ND	ND	ND
HEXANE	0.00019	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND
2-BUTENAL	0.02059	ND	ND	ND
1,2-DICHLOROETHANE	0.03500	ND	ND	ND
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND
N-BUTANOL	0.00832	0.00063	ND	ND
BENZENE	0.17500	ND	ND	ND
TETRACHLOROMETHANE	ND	ND	ND	ND
2-PENTANONE	0.00050	0.00036	ND	0.00036
2-METHYLHEXANE	0.00121	ND	ND	ND
2,3-DIMETHYLPENTANE	0.00017	ND	ND	ND
PENTANAL	0.00660	0.00472	0.00660	0.00472
3-METHYLHEXANE	0.00121	ND	ND	ND
1,2-DICHLOROPROPANE	ND	ND	ND	ND
1,4-DIOXANE	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND
2,5-DIMETHYLFURAN	ND	ND	ND	ND

CHEMICAL CONTAMINANT	T-VALUE (180-day SMAC)				
	AA03933 LAB S/N 1019 09/08/05 @ 05:05 GMT	AA03935 SM S/N 1018 09/08/05 @ 15:15 GMT	AA03934 FGB S/N 1017 09/30/05 @ 09:55 GMT	AA03936 SM S/N 1016 09/30/05 @ 10:00 GMT	
	HEPTANE	0.00018	ND	ND	ND
	4-METHYL-2-PENTANONE	ND	ND	ND	ND
	CIS-1,3-DICHLOROPROPENE	ND	ND	ND	ND
2-PENTENAL	0.01667	ND	ND	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND
TOLUENE	0.01694	0.00042	ND	ND	ND
HEXANAL	0.00574	0.00410	0.00574	0.00410	
MESITYL OXIDE	0.00088	ND	ND	ND	ND
1,2-DIBROMOETHANE	ND	ND	ND	ND	ND
BUTYL ACETATE	0.00018	ND	ND	ND	ND
TETRACHLOROETHENE	0.00103	ND	ND	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND
ETHYLBENZENE	0.00070	ND	ND	ND	ND
META+PARA-XYLEMES	0.00016	ND	ND	ND	ND
2-HEPTANONE	0.00152	ND	ND	ND	ND
CYCLOHEXANONE	0.00058	0.00042	ND	ND	ND
HEPTANAL	0.00500	ND	ND	ND	ND
STYRENE	0.00081	ND	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND	ND	ND
ORTHO-XYLENE	0.00043	0.00011	ND	ND	ND
1,3,5-TRIMETHYLBENZENE	ND	ND	ND	ND	ND
1,2,4-TRIMETHYLBENZENE	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND
HEXACHLOROBUTADIENE	ND	ND	ND	ND	ND

TARGET COMPOUNDS (TOXIC)				
1,3-BUTADIENE	ND	ND	ND	ND
ETHYLENE OXIDE	ND	ND	ND	ND
CARBON DISULFIDE	0.00219	0.00156	0.00219	0.00156
2-METHYL-2-PROPENAL	0.02059	0.01471	0.02059	ND
3-BUTEN-2-ONE	0.08140	0.05814	0.08140	ND
2-ETHOXYETHANOL	ND	ND	ND	ND
DIMETHYLDISULFIDE	ND	ND	ND	ND
OCTAMETHYLCYCLOTETRAKSILOXANE	0.02978	0.02246	0.06713	0.00208

NON-TARGET COMPOUNDS				
OCTAFLUOROPROPANE	*	*	*	*
1,1,1,2-TETRAFLUOROETHANE	0.00034	ND	ND	ND
CARBONYLSULFIDE	0.01469	0.01082	0.00611	0.00874
1-BUTENE	0.00008	0.00005	0.00008	0.00005
TRIMETHYLSILANOL	0.00805	0.00068	0.00095	ND
1,3-DIOXOLANE	0.04821	0.00069	0.00097	0.00069
HEXAMETHYLCYCLOTETRAKSILOXANE	0.01599	0.04469	0.05527	0.00816
LIMONENE	0.00012	0.00004	0.00006	0.00004

TOTAL T-VALUE	3.17646	0.20559	1.19541	0.06149
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CHEMICAL CONTAMINANT	T-VALUE (180-day SMAC)			
	AA03933 LAB S/N 1019 09/08/05 @ 05:05 GMT	AA03935 SM S/N 1018 09/08/05 @ 15:15 GMT	AA03934 FGB S/N 1017 09/30/05 @ 09:55 GMT	AA03936 SM S/N 1016 09/30/05 @ 10:00 GMT

* Present, but not calculated

ND : Value is less than the laboratory report detection limit.

Note: Number of decimal places in T-Values do not represent significant figures of measurements.

***Measurements are calibrated by multi-point initial calibration and verified by mid-point continuing calibration.